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### Description

#### Electric machine

Electric machine with a rotor and a stator, in which electric coils and permanent magnets are located which influence each other when the rotor revolves, where the rotor contains the magnets and the stator contains the coils and the coils do not have an iron core and at least one section of the coils extends transversely across the circumference of the rotor.

A machine of this kind has already been disclosed in EP-B-0 422 539.

The purpose of the invention is to improve this machine.

In the solution to this problem proposed by the invention, the coils are fitted in the stator individually and are bent in such a way that they extend on both sides of the rotor and enclose the magnets located in the rotor to a large extent.

The fact that the magnets are enclosed by the individual coils leads to the achievement of a very high degree of efficiency, while both production and maintenance are simplified considerably by the provision of individual coils.

In accordance with an advantageous development of the invention, it is provided that the magnets are cylindrical and are located at least approximately tangentially on the circumference of the rotor.

This configuration makes it simple to adjust the magnets and the coils.

In another advantageous development of the invention, the permanent magnets are attached to the rotor via support elements.

This has the effect that the magnets can be replaced easily if this is required.

It is also very advantageous if in accordance with a further development of the invention the coils have a  $\Omega$ -shaped cross-section and the magnets are immediately next to the inside of the coils.

A particularly high degree of machine efficiency is reached as a result.

In another advantageous development of the invention, the support elements for the magnets are attached to the rotor in such a way that they can be replaced.

This makes it particularly easy to remove the magnets from the machine and to fit them back on it again.

It has also proved to be particularly advantageous if an interlocking facility is provided between the magnets and/or their support elements and the rotor, preferably in the radial direction.

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A secure connection is established between the magnet and/or support element and the rotor as a result. High centrifugal forces that are produced are compensated for effectively.

It is also very advantageous if the magnets and/or their support elements are attached to the rotor so that they can be removed in the axial direction.

This guarantees that the magnets are simple to remove from the rotor.

It is also very advantageous if in accordance with a further development of the invention the connections for the coil are located so that they are accessible individually on the stator.

This makes it simple to check every individual coil if a fault occurs.

It has proved to be very advantageous if in accordance with a further development of the invention the magnets located behind each other have different polarity in each case.

The machine achieves a particularly high power yield as a result.

It is also particularly favourable if in accordance with a further development of the invention a pole reversal device is provided in the supply line to the coils.

As a result of this, the electric machine can on the one hand be operated with direct current voltage before the pole reversal device and with alternating current voltage after the pole reversal device when it is used as a motor, while alternating current voltage can on the other hand be tapped before the pole reversal device and direct current voltage can be tapped after the pole reversal device when the electric machine is used as a generator.

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It has proved to be very favourable if in accordance with a further development of the invention the coil is annular and the profiles of the rotor and coil are adapted to each other.

A further advantageous development of the invention is characterised by the fact that several rotors and coil configurations are located behind each other in the axial direction of the machine.

It is also very favourable if in accordance with a further development of the invention at least two machines preferably in the form of motors with different diameters are located behind each other on a mutual machine shaft.

The different diameters mean that the motors have different torques, which can be very advantageous when the machine starts up in particular.

It has also proved to be extremely advantageous if the coils are formed from several coils that are only one wire layer thick in each case.

Easier and more precise shaping of the coils is possible as a result.

It is very advantageous in this context if the connections for the individual coils are wired individually and are in particular designed so that they can be connected in series and/or parallel.

It has also proved to be very advantageous if the individual coil layers are in particular glued together with an adhesive that conducts heat effectively.

This construction guarantees optimum coil design and good heat dissipation.

It is advantageous in this context if the housing has at least one air inlet opening in the immediate vicinity of the machine shaft.

It is also very advantageous in this context if the housing has at least one air outlet opening at least close to the point where the circumference is largest.

The air sucked in through the air inlet opening is accelerated towards where the rotor circumference is largest by the rotary movement of the rotor and leaves the housing via the air outlet opening. The machine is cooled effectively as a result. Optimum flow over and around the coils is guaranteed as a result.

In a further advantageous development of the invention, the air outlet is connected to the air inlet via a heat exchanger provided between them.

This is an effective way to remove the waste heat of the machine and possibly to use it for another purpose.

It has proved to be very advantageous in this context if the heat exchanger transfers the heat of the machine to a gaseous or liquid medium.

It is also very advantageous if the heat exchanger transfers the machine heat to a solid medium and in particular if the heat exchanger is designed to be a geothermal heat exchanger.

It is extremely advantageous if in accordance with a further development of the invention a particle filter is provided on the air inlet.

Particles that are harmful to the machine are kept away from the inside of the housing as a result.

It has proved to be advantageous in this context if the particle filter has at least one fine metallic screen.

This guarantees that the fine screen can be cleaned and reused even when it has become very dirty.

It is in addition extremely advantageous if a magnet, particularly a permanent magnet, is located with one pole on the fine screen.

This is an effective way to keep out magnetic particles that could have the greatest impact on the machine.

It is very advantageous in this context if a connection is established between a second fine screen and the second pole of the magnet.

Any magnetic particles that manage to get through the first fine screen nevertheless are as a result stopped by the second fine screen.

It is also extremely advantageous if the fine screens are configured in such a way that they can be separated from the magnet.

The particles that have been caught are particularly easy to remove from the fine screen(s) after they have been separated from the magnet.

In another advantageous development of the invention, a filter is provided that is able to filter particles out of the flow of air that can be influenced electrically and/or magnetically.

Electrically charged particles that have a negative effect on the machine can also be kept out of the inside of the housing as a result.

In another advantageous development of the machine, the housing is designed in such a way that effective heat transmission is guaranteed between the housing and the surroundings.

This enables the machine to be operated without any danger of overheating even when it is completely enclosed.

Several different embodiments of the invention are illustrated in the drawings:

Fig.1 is a cross-section of a machine with cylindrical magnets and  $\Omega$ -shaped coils,

Fig.2 is a side view of the machine showing the stator,

Fig.3 is a side view of the rotor with permanent magnets that are arranged to permit their removal,

Fig.4 is a side view of a machine that has been disassembled to some extent,

Fig.5 is a cross-section of another machine,

Fig.6 is a side view of the machine shown in Fig. 5,

Fig.7 is a side view of a magnet interlocked with the rotor,

Fig.8 is a tangential view of the rotor with the same interlocked magnet,

Fig.9 is a partial side view of a stator, that is covered on the outside with concentric rings made of wire,

Fig.10 is a cross-section of another machine, which on the one hand has wire rings as shown in Fig. 9, while a cable support is located above the stator,

Fig.11 shows a machine enclosed in a housing, with a heat exchanger to remove the waste heat of the machine,

Fig.12 shows a further machine enclosed in a housing, with a geothermal heat exchanger to remove the waste heat of the machine,

Fig.13 shows another machine enclosed in a housing, with air inlet openings protected by filters and with a discharge air duct and

Fig.14 is a cross-section of a filter assembly with two fine screens and a permanent magnet.

1 in Fig. 1 is a machine that can be used either as a motor or as a generator. A rotor 3 to which support elements 4 are attached is located on a shaft 2. Cylindrical permanent magnets 5 are provided on the outer end of these support elements 4. These permanent magnets 5 are surrounded by  $\Omega$ -shaped coils 6 leaving a small air gap between them, the coils 6 in turn being fixed in the stator section 7.

A side view of the stator 7 is shown in Fig. 2, where four coils 6 are provided. The connection lines 8 for the coils 6 have been wired outwards, so that the coils 6 can be checked without the need for any dismantling if a fault occurs.

As is shown in the two Figures 3 and 4, not only the permanent magnets 5 together with their support elements 4 but also the coils can be removed easily

and can be refitted just as easily. Only the part concerned therefore has to be replaced in each case when repairs are needed.

In the embodiment shown in Figures 5 and 6, the shaft 52 of the machine 51 supports a rotor 53 with a larger diameter, to which the permanent magnets 5 are attached directly. Since the permanent magnets are difficult to fit and remove in this configuration, the coils 56 have a U-shaped cross-section. When appropriate covers have been taken off the stator housing, the coils 56 can be removed easily. The coil connections 8 are provided on the outside here too so that checks are simple to make.

Fig. 7 shows a rotor 71 with openings 72, the radial sides 73 of which dovetail outwards. Permanent magnets 5, the shape of which corresponds to the shape of the openings 72, are fitted in these openings from the axial direction. The permanent magnets 5 are attached in the axial direction by screws 74 that are shown in Fig. 8 and that engage holes 75 drilled at the places where the openings 72 are widest. The permanent magnets 5 are held securely in the radial direction due to the dovetailed interlocking of the permanent magnets 5 with the rotor 71. The centrifugal forces that are produced in the radial direction during operation and act on the permanent magnets 5 are compensated for in this way. It needs to be easy for the permanent magnets 5 to be removed in the axial direction, so they are only attached by two screws 74, as a result of which the magnets 5 are simple to replace.

In order to minimise undesirable effects on the environment due to the permanent magnets 5 rotating in the machine 1, concentric rings 9 made of insulated wire are provided on the outside of the stator 7 and outside the coils 6, as is shown in Fig. 9. The magnetic alternating fields of the rotating permanent magnets 5 generate currents in the rings 9 that are converted into heat.

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The machine 111 that is shown in Fig. 11 is surrounded completely by a housing 12. A discharge air duct 13, which leads to the air inlet opening 11 via a heat exchanger 14, is located where the housing 12 is radially widest. This means that the machine 111 is cooled by a self-contained air circulation system, so that no contaminants can get inside the machine housing 12 via the cooling system. This machine 111 can therefore be used even under extreme conditions. The waste heat is removed by the heat exchanger 14 via a duct system that is not shown in any detail in the drawing using a gaseous or liquid medium. Another conceivable possibility in this context is to take advantage of the latent heat of a medium in the heat exchanger 14. It is also possible to use a geothermal heat exchanger 15 to remove the waste heat of the machine 111. The waste heat of the machine 111 is then fed into a solid medium such as a cool layer of earth.

Filters 16 that filter out particles which would be harmful to the machine 131 are provided on the air inlet openings 11 of the housing 12 to filter the air supplied to an open cooling air system of another machine 131. The filters 16 consist essentially of two fine metallic screens 17 and 18, each of which is connected to one pole of a permanent magnet 19. Due to the magnetism of the permanent magnet 19, magnetic particles that could pass through the fine screens 17 and 18 because they are smaller than the mesh in them are attracted magnetically to the fine screens 17 and 18. The fine screens 17 and 18 are designed in such a way

that they can be separated from the permanent magnet 19, as a result of which it is simple to clean off the magnetic particles that have settled on them.

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